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SPECIFICATION

TENNIS SHOES

TECHNICAL FIELD

The present invention relates to tennis shoes. More particularly, the present invention relates to an improvement in the bottom faces of the tennis shoes.

BACKGROUND ART

In the rally of tennis, a player makes a stroke while heavily moving in a court. The player predicts the direction of a ball from the stroke of an opponent and moves toward a target spot. Feet kick a ground to carry out the movement. When approaching the target spot, the player stops the kicks and recovers the balance of the stroke. Then, the feet of the player take a slide on the ground. The body of the player is moved forward by the slide at a short distance. Most of the movement to the target spot is carried out by kicking and the movement in a final stage is performed by the slide. The player reaching the target spot makes a stroke. Next, the player inverts the body to kick the ground, thereby moving to a next target spot.

It is preferable that the tennis shoes and the ground do not cause the slip in the movement carried out by the kicks. A nonslip performance is required for the tennis shoes. On the other hand, it is preferable that the tennis shoes and the ground should slip properly in the movement carried out by the slide. A sliding performance is required for the tennis shoes. Japanese Laid-Open Patent Publication No. Hei 7-213304 has disclosed tennis shoes in which the planar shape of the projection of a bottom face is devised to cause the nonslip performance and the sliding performance to be consistent with each other.

Also in the tennis shoes disclosed in the publication described above, the nonslip performance and the sliding performance are not sufficiently consistent with each other. It is an object of the present invention to provide tennis shoes which are excellent in the nonslip performance and the sliding performance.

DISCLOSURE OF THE INVENTION

Tennis shoes according to the present invention comprise a large number of ridges arranged on bottom faces. The ridge has a cross section taking an asymmetrical shape. A ratio ($\mu a/\mu b$) of a coefficient of friction μa in one direction of the bottom face to a coefficient of friction μb in a reverse direction is 0.3 to 0.9. The tennis shoes are excellent in a sliding performance in one direction and a nonslip performance in a reverse direction.

Tennis shoes according to another invention comprise a large number of lateral ridges extended in a transverse direction on bottom faces. The lateral ridge has a cross section taking an asymmetrical shape. A ratio ($\mu a/\mu b$) of a coefficient of friction μa in a toe direction of the bottom face to a coefficient of friction μb in a heel direction is 0.3 to 0.9. The tennis shoes are excellent in a sliding performance in the toe direction and a nonslip performance in the heel direction.

The lateral ridge includes a contact surface, and a toe side wall surface and a heel side wall surface which are linked to the contact surface. It is preferable that a difference ($\theta b - \theta a$) between an inclination angle θa of the toe side wall surface and an inclination angle θb of the heel side wall surface should be 10 degrees to 60 degrees. The lateral ridge has a preferable height of 1mm to 8 mm.

It is preferable that the tennis shoes should comprise

a longitudinal ridge in addition to the lateral ridge. The longitudinal ridge is extended in a longitudinal direction. The lateral ridge is mainly formed in a region provided on a toe side from a center of the bottom face in the longitudinal direction at an outside of a center in a transverse direction. The longitudinal ridge is mainly formed in a region provided on the toe side from the center of the bottom face in the longitudinal direction at an inside from the center in the transverse direction. The tennis shoes are excellent in a sliding performance and a nonslip performance in a forward movement and the nonslip performance in the change of a direction.

Tennis shoes according to yet another invention comprise a large number of lateral ridges and a large number of longitudinal ridges on bottom faces thereof. A ratio R1 of a contact area of the lateral ridges to a total contact area in a toe portion is 40% to 70%. A ratio R2 of a contact area of the longitudinal ridges to the total contact area in an inside portion is 70% to 100%. The tennis shoes are excellent in the nonslip performance and the sliding performance.

It is preferable that the lateral ridge should take an asymmetrical sectional shape in a longitudinal direction of the shoes and the longitudinal ridge should also take an asymmetrical sectional shape in a transverse direction of the shoes. A coefficient of friction μa in a toe direction of the bottom face and the contact surface is smaller than a coefficient of friction μb in a heel direction. A ratio $(\mu a/\mu b)$ of μa to μb is 0.3 to 0.9.

It is preferable that the ratio R1 should be 45% to 65% and the ratio R2 should be 75% to 95%. It is preferable that the ratio R1 should be 50% to 60% and the ratio R2 should be 80% to 90%.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view showing a tennis shoe according to an embodiment of the present invention,

Fig. 2 is a bottom view showing the tennis shoe in Fig. 1,

Fig. 3 is a perspective view showing a part of a sole in Fig. 2 as seen from below,

Fig. 4 is an enlarged sectional view showing a part of the sole in Fig. 2,

Fig. 5 is a sectional view showing a part of the sole of a tennis shoe according to another embodiment of the present invention,

Fig. 6 is a sectional view showing a part of the sole of a tennis shoe according to yet another embodiment of the present invention,

Fig. 7 is a bottom view showing the sole of a tennis shoe according to a further embodiment of the present invention,

Fig. 8 is an enlarged sectional view showing a part of the sole in Fig. 7,

Fig. 9 is a bottom view showing the sole of a tennis shoe according to a further embodiment of the present invention,

Fig. 10 is a perspective view showing a part of the sole in Fig. 9 as seen from below,

Fig. 11 is an enlarged sectional view showing a part of the sole in Fig. 10,

Fig. 12 is an enlarged sectional view showing a part of the sole in Fig. 9,

Fig. 13 is a bottom view showing a part of a sole according to a further embodiment of the present invention,

Fig. 14 is a bottom view showing the sole of a tennis shoe according to a further embodiment of the present invention, and

Fig. 15 is an enlarged bottom view showing a part of the sole in Fig. 14.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention will be described below in detail based on embodiments with reference to the drawings.

A tennis shoe 1 shown in Fig. 1 comprises an upper 3 and a sole 5. The material of the upper 3 is equivalent to that of the upper of a well-known tennis shoe. The material of the sole 5 is equivalent to that of the sole of the well-known tennis shoe. In general, the sole 5 is constituted by a crosslinked rubber or a synthetic resin.

Fig. 2 shows the sole 5. In Fig. 2, an upper side indicates a toe side, a lower side indicates a heel side, a right side indicates an outside and a left side indicates an inside. The sole 5 is used for a left foot. A sole for a right foot takes a shape obtained by inverting the shape shown in Fig. 2.

The sole 5 includes a base 7 and a large number of lateral ridges 9. The lateral ridge 9 is formed integrally with the base 7 and is protruded from the base 7. The lateral ridge 9 is extended in a transverse direction in Fig. 2. A large number of lateral ridges 9 are arranged in parallel at a predetermined interval. The lateral ridge 9 is not present in a region corresponding to the arch of a foot. In this specification, the lateral ridge 9 implies a ridge extended in an almost orthogonal direction to the longitudinal direction of the sole 5. It is preferable that the direction of the extension of the lateral ridge 9 should be set at 80 degrees to 100 degrees with respect to the longitudinal direction of the sole 5.

Fig. 3 is a perspective view showing a part of the sole 5 in Fig. 2 as seen from below and Fig. 4 is an enlarged sectional view showing a part thereof. In these drawings, a left side indicates a toe side and a right side indicates a heel side. As is apparent from Figs. 3 and 4, the sectional shape of the lateral ridge 9 is asymmetrical. The lateral ridge 9 has a

contact surface 11, a toe side wall surface 13 and a heel side wall surface 15. The contact surface 11 comes in contact with a ground when the tennis shoe 1 is put on. The toe side wall surface 13 is linked to the contact surface 11 and is positioned on a toe side from the contact surface 11. The heel side wall surface 15 is linked to the contact surface 11 and is positioned on a heel side from the contact surface 11.

In Fig. 4, an arrow θa indicates the inclination angle of the toe side wall surface 13. The inclination angle θa is formed by the toe side wall surface 13 with respect to a horizontal plane G (ground). In Fig. 4, an arrow θb indicates the inclination angle of the heel side wall surface 15. The inclination angle θb is formed by the heel side wall surface 15 with respect to the horizontal plane G. The inclination angle θb is greater than the inclination angle θa.

In the case in which the tennis shoe 1 is put on the ground and is pulled in the toe direction, a tensile force is mainly applied to the toe side wall surface 13. Since the inclination of the toe side wall surface 13 is small, a coefficient of friction μa between the ground and the bottom face is small. In the case in which a player slides the shoes, a sliding direction thereof is set to be the toe direction. Since the tennis shoe 1 has the small coefficient of friction μa, a sliding performance is excellent. A player putting on the tennis shoe 1 can smoothly carry out a transition from a movement to a stroke. A slide also contributes to the relaxation of a shock in a landing.

In the case in which the tennis shoe 1 is put on the ground and is pulled in the heel direction, a tensile force is mainly applied to the heel side wall surface 15. Since the inclination of the heel side wall surface 15 is great, a coefficient of friction μb between the ground and the bottom face is great. In the case in which the player kicks the ground to move forward,

a kicking direction is set to be the heel direction. Since the tennis shoe 1 has the great coefficient of friction μb, a nonslip performance is excellent in the kicking.

In respect of the consistency of the sliding performance and the nonslip performance, a ratio ($\mu a/\mu b$) of the coefficient of friction μa to the coefficient of friction μb is preferably equal to or lower than 0.9 and is more preferably equal to or lower than 0.7. If the ratio ($\mu a/\mu b$) is too low, an unintended slip is apt to be caused in the toe direction. For this reason, the ratio ($\mu a/\mu b$) is preferably equal to or higher than 0.3 and is more preferably equal to or higher than 0.5.

The coefficient of friction is measured over an artificial turf having sand on the following conditions (1) and (2).

(1) Pile

Material : polypropylene

Shape : split yarn

Thread : 8400 decitex

Latitudinal density of pile (gauge) : interval of 5/16 inch

Longitudinal density of pile (stitch) : 4.8 stitches / inch

Height from surface of foundation cloth to tip : 19 mm

(2) Sand to be filled

Type : Dry sand of which grain sizes are controled (a trade name of "OMNISAND A" manufactured by SUMITOMO RUBBER INDUSTRIES, LTD.)

Amount of filling : 25 kg/m^2

Height of filling : filling to leave tip of artificial turf by 2 mm

In the measurement, a vertical load of 600 N is applied to the tennis shoe 1 over the artificial turf having sand and

a force in a horizontal direction is applied in such a manner that the tennis shoe 1 is pulled in a predetermined direction at a speed of 50 cm/s. The tensile force is detected by a load cell and is divided by the vertical load so that a coefficient of friction is calculated. The measurement is carried out in an environment of 20℃.

In respect of the consistency of the sliding performance and the nonslip performance, a difference ($\theta b - \theta a$) is preferably equal to or greater than 10 degrees and is more preferably equal to or greater than 20 degrees. Since the difference ($\theta b - \theta a$) is excessively great, an unintended slip is apt to be caused in the toe direction. For this reason, the difference ($\theta b - \theta a$) is preferably equal to or smaller than 60 degrees and is more preferably equal to or smaller than 50 degrees. It is preferable that the inclination angle θa should be 30 degrees to 70 degrees. It is preferable that the inclination angle θb should be 50 degrees to 90 degrees.

It is preferable that a height H of the lateral ridge 9 should be 1 mm to 8 mm. In some cases in which the height H is smaller than the range, the nonslip performance is insufficient. In this respect, it is more preferable that the height H should be equal to or greater than 2 mm. In some cases in which the height H is greater than the range, the stiffness of the lateral ridge 9 is insufficient. From this viewpoint, it is more preferable that the height H should be equal to or smaller than 6 mm.

It is preferable that a ratio (L2/L1) of a distance L2 of the contact surface 11 to a distance L1 of a boundary portion between the base 7 and the lateral ridge 9 should be 0.2 to 0.8. In some cases in which the ratio (L2/L1) is smaller than the range, the stiffness of the lateral ridge 9 is insufficient. From this viewpoint, it is more preferable that the ratio (L2/L1) should be equal to or higher than 0.3. In some cases

in which the ratio (L2/L1) is higher than the range, a contact pressure becomes lacking so that the nonslip performance is insufficient. From this viewpoint, it is particularly preferable that the ratio (L2/L1) should be equal to or lower than 0.6.

It is preferable that a ratio of the total area of all the contact surfaces to the projection area of the bottom face should be 15% to 70%. If the ratio is lower than the range, the contact surface is apt to be worn out. From this viewpoint, it is more preferable that the ratio should be equal to or higher than 25%. In some cases in which the ratio is higher than the range, the contact pressure becomes lacking so that the nonslip performance is insufficient. From this viewpoint, it is more preferable that the ratio should be equal to or lower than 60%.

While the lateral ridge 9 is extended in the transverse direction in the tennis shoe 1 shown in Fig. 2, it may be extended in another direction. Also in this case, an excellent sliding performance can be achieved in one direction which is orthogonal to the lateral ridge 9 and an excellent nonslip performance can be achieved in a reverse direction.

Fig. 5 is a sectional view showing a part of a sole 17 of a tennis shoe according to another embodiment of the present invention. In Fig. 5, a lateral ridge 19 and a base 21 are shown. In Fig. 5, a left side indicates a toe side and a right side indicates a heel side. The sectional shape of the lateral ridge 19 is asymmetrical. The lateral ridge 19 includes a contact surface 23, a toe side wall surface 25 and a heel side wall surface 27. The toe side wall surface 25 is curved. The sole 17 comprises a large number of lateral ridges 19 arranged in parallel in the same manner as the sole 5 shown in Fig. 2.

In Fig. 5, a two-dotted chain line indicates a virtual line connecting a boundary point P1 between the contact surface 23 and the toe side wall surface 25 and a boundary point P2

between the base 21 and the toe side wall surface 25. An angle formed by the virtual line and a horizontal line G is indicated as an inclination angle θa of the toe side wall surface 25. Also in this sole, it is preferable that the inclination angle θa should be 30 degrees to 70 degrees. On the other hand, it is preferable that an inclination angle θb of the heel side wall surface 27 should be 50 degrees to 90 degrees. In respect of the consistency of a sliding performance and a nonslip performance, a difference ($\theta b - \theta a$) is preferably equal to or greater than 10 degrees and is more preferably equal to or greater than 20 degrees. If the difference ($\theta b - \theta a$) is excessively great, an unintended slip is apt to be caused in a toe direction. For this reason, the difference ($\theta b - \theta a$) is preferably equal to or smaller than 60 degrees and is more preferably equal to or smaller than 50 degrees.

Also in this sole 17, it is preferable that a height H of the lateral ridge 19 should be 1 mm to 8 mm. Also in this sole 17, it is preferable that a ratio (L2/L1) should be 0.2 to 0.8.

Also in this sole 17, in respect of the consistency of the sliding performance and the nonslip performance, a ratio ($\mu a / \mu b$) of a coefficient of friction μa to a coefficient of friction μb is preferably equal to or lower than 0.9 and is more preferably equal to or lower than 0.7. If the ratio ($\mu a / \mu b$) is excessively low, an unintended slip is apt to be caused in the toe direction. For this reason, the ratio ($\mu a / \mu b$) is preferably equal to or higher than 0.3 and is more preferably equal to or higher than 0.5.

Fig. 6 is a sectional view showing a part of a sole 29 of a tennis shoe according to yet another embodiment of the present invention. In Fig. 6, a lateral ridge 31 and a base 33 are shown. In Fig. 6, a left side indicates a toe side and a right side indicates a heel side. The sectional shape of the

lateral ridge 31 is asymmetrical. The lateral ridge 31 includes a contact surface 35, a toe side wall surface 37 and a heel side wall surface 39. The contact surface 35 is curved. The contact surface 35 is narrower than the contact surface 11 of the lateral ridge 9 shown in Fig. 4. The sole 29 comprises a large number of lateral ridges 31 arranged in parallel in the same manner as the sole 5 shown in Fig. 2.

Also in this sole 29, it is preferable that an inclination angle θa formed by the toe side wall surface 37 with respect to a horizontal plane should be 30 degrees to 70 degrees. On the other hand, it is preferable that an inclination angle θb formed by the heel side wall surface 39 with respect to the horizontal plane should be 50 degrees to 90 degrees. In respect of the consistency of a sliding performance and a nonslip performance, a difference ($\theta b - \theta a$) is preferably equal to or greater than 10 degrees and is more preferably equal to or greater than 20 degrees. If the difference ($\theta b - \theta a$) is excessively great, an unintended slip is apt to be caused in a toe direction. For this reason, the difference ($\theta b - \theta a$) is preferably equal to or smaller than 60 degrees and is more preferably equal to or smaller than 50 degrees.

Also in this sole 29, it is preferable that a height H of the lateral ridge 31 should be 1 mm to 8 mm. Also in this sole 29, it is preferable that a ratio (L2/L1) should be 0.2 to 0.8.

Also in this sole 29, in respect of the consistency of the sliding performance and the nonslip performance, a ratio ($\mu a / \mu b$) of a coefficient of friction μa to a coefficient of friction μb is preferably equal to or lower than 0.9 and is more preferably equal to or lower than 0.7. If the ratio ($\mu a / \mu b$) is excessively low, an unintended slip is apt to be caused in the toe direction. For this reason, the ratio ($\mu a / \mu b$) is preferably equal to or higher than 0.3 and is more preferably

equal to or higher than 0.5.

Fig. 7 is a bottom view showing a sole 41 of a tennis shoe according to a further embodiment of the present invention. In Fig. 7, an upper side indicates a toe side, a lower side indicates a heel side, a right side indicates an outside and a left side indicates an inside. The sole 41 is used for a left foot. A sole for a right foot takes a shape obtained by inverting the shape shown in Fig. 7.

The sole 41 includes a base 43, a large number of lateral ridges 45 and a large number of longitudinal ridges 47. The lateral ridge 45 and the longitudinal ridge 47 are formed integrally with the base 43 and are protruded from the base 43. The lateral ridge 45 is extended in a transverse direction in Fig. 7. The longitudinal ridge 47 is extended in a longitudinal direction. In this specification, the longitudinal ridge 47 implies a ridge extended in almost parallel with the longitudinal direction of the sole 41. It is preferable that the direction of the extension of the longitudinal ridge 47 should be set at -10 degrees to 10 degrees with respect to the longitudinal direction of the sole 41. The sectional shape and dimension of the lateral ridge 45 is equivalent to the sectional shape of the lateral ridge 9 shown in Fig. 4

Fig. 8 is an enlarged sectional view showing a part of the sole 41 in Fig. 7. In Fig. 8, the longitudinal ridge 47 is shown. In Fig. 8, a left side indicates an inside and a right side indicates an outside. As is apparent from Fig. 8, the longitudinal ridge 47 includes a contact surface 49, an inside wall surface 51 and an outside wall surface 53. An inclination angle θc of the inside wall surface 51 with respect to a horizontal direction is smaller than an inclination angle θd of the outside wall surface 53 with respect to the horizontal direction.

A one-dotted chain line CL1 shown in Fig. 7 is a center

line in a longitudinal direction. When the longest segment which can be drawn in the contour line of the sole 41 is assumed, the center line CL1 is a straight line which is orthogonal to the longest segment on the center of the longest segment. A virtual line Li is a straight line which is tangent to the inside of the sole 41 in parallel with the longest segment. A virtual line Lo is a straight line which is tangent to the outside of the sole 41 in parallel with the longest segment. A distance between the virtual line Li and the virtual line Lo is a width W of the sole 41. A one-dotted chain line CL2 shown in Fig. 7 indicates a center line in a transverse direction. The center line CL2 is parallel with the virtual lines Li and Lo.

A portion provided above the center line CL1 at the right side of the center line CL2 in the bottom face is a region placed on the toe side from a center in a longitudinal direction at the outside of the center in the transverse direction. The lateral ridge 45 is mainly formed in this region. More specifically, the contact area of the lateral ridge 45 occupying in the contact area of all the ridges 45 and 47 included in this region is equal to or greater than 50%, and particularly, is equal to or greater than 70%. When the player kicks the ground to move forward and slides the tennis shoes while moving forward, a great load is applied to this region. The lateral ridge 45 is mainly formed in this region so that a sliding performance and a nonslip performance are consistent with each other.

A portion provided above the center line CL1 at the left side of the center line CL2 in the bottom face is a region placed on the toe side from a center in a longitudinal direction at the inside of the center in the transverse direction. The longitudinal ridge 47 is mainly formed in this region. More specifically, the contact area of the longitudinal ridge 47 occupying in the contact area of all the ridges 45 and 47 included in this region is equal to or greater than 50%, and particularly,

is equal to or greater than 70%. When the player changes a direction, a great load is applied to this region. The longitudinal ridge 47 is mainly formed in this region so that a nonslip performance in the change of the direction can be enhanced. The outside wall surface 53 mainly contributes to the enhancement in the nonslip performance. Since the inclination of the inside wall surface 51 is small, the area of the contact surface 49 is small in the longitudinal ridge 47. A contact pressure can be raised by the contact surface 49 having the small area. A high contact pressure contributes to an enhancement in the nonslip performance.

It is preferable that the inclination angle θc formed by the inside wall surface 51 with respect to a horizontal plane should be 30 degrees to 70 degrees. On the other hand, it is preferable that the inclination angle θd formed by the outside wall surface 53 with respect to the horizontal plane should be 50 degrees to 90 degrees. In respect of the nonslip performance, a difference (θd - θc) is preferably equal to or greater than 10 degrees and is more preferably equal to or greater than 20 degrees. The difference (θd - θc) is preferably equal to or smaller than 60 degrees and is more preferably equal to or smaller than 50 degrees.

It is preferable that a height H of the longitudinal ridge 47 should be 1 mm to 8 mm. It is preferable that a ratio (L4/L3) of a distance L4 of the contact surface 49 to a distance L3 of a boundary portion between the base 43 and the longitudinal ridge 47 should be 0.2 to 0.8.

Also in the sole 41, in respect of the consistency of the sliding performance and the nonslip performance, a ratio ($\mu a/\mu b$) of a coefficient of friction μa to a coefficient of friction μb is preferably equal to or lower than 0.9 and is more preferably equal to or lower than 0.7. If the ratio ($\mu a/\mu b$) is too low, an unintended slip in the toe direction

is apt to be caused. For this reason, the ratio ($\mu a/\mu b$) is preferably equal to or higher than 0.3 and is more preferably equal to or higher than 0.5.

Also in the sole 41, it is preferable that a ratio of the total area of all the contact surfaces to the projection area of the bottom face should be 15% to 70%. If the ratio is lower than the range, the contact surface is apt to be worn out. From this viewpoint, it is more preferable that the ratio should be equal to or higher than 25%. In some cases in which the ratio is higher than the range, the nonslip performance becomes insufficient. From this viewpoint, it is more preferable that the ratio should be equal to or lower than 60%.

Fig. 9 is a bottom view showing a sole 55 of a tennis shoe according to a further embodiment of the present invention. In Fig. 9, an upper side indicates a toe side, a lower side indicates a heel side, a right side indicates an outside and a left side indicates an inside. A portion of a bottom face which is provided above a center line CL1 indicates a toe portion. A left side of a center line CL2 indicates an inside portion. The sole 55 is used for a left foot. A sole for a right foot takes a shape obtained by inverting the shape shown in Fig. 9.

The sole 55 comprises a base 57 and a ridge 59. The ridge 59 is formed integrally with the base 57 and is protruded from the base 57. The ridge 59 has a plurality of lateral ridges 61 and a plurality of longitudinal ridges 63. The lateral ridge 61 is extended in a transverse direction. The longitudinal ridge 63 is extended in a longitudinal direction. The lateral ridges 61 are arranged in a plurality of lines in parallel at a predetermined interval in a longitudinal direction. The longitudinal ridges 63 are arranged in the same lines in the transverse direction.

A plurality of lateral ridges 61 is arranged on the outside of the toe portion. The longitudinal ridges 63 are mainly

arranged in a region to be the tow portion and the inside portion. The longitudinal ridges 63 are arranged in parallel below the center line CL1 in the longitudinal direction. The ridge 59 is not present in a region corresponding to the arch of a foot.

In case of Fig. 9, the contact area of the sole 55 is obtained by the total of the contact area of the lateral ridge 61 and that of the longitudinal ridge 63. In the toe portion, a ratio R1 (%) of the contact area of the lateral ridge 61 to the total contact area is expressed in the following equation (I)

$$R1 = (Sxt / (Sxt + Syt)) \cdot 100 \quad (I)$$

In the equation (I), Sxt represents the contact area of the lateral ridge 61 in the toe portion and Syt represents the contact area of the longitudinal ridge 63 in the toe portion. The ridge 59 is formed to have the ratio R1 of 40% to 70%. The ratio R1 is more preferably 45% to 65% and is particularly preferably 50% to 60%.

In the inside portion, a ratio R2 (%) of the contact area of the longitudinal ridge 63 to the total contact area is expressed in the following equation (II).

$$R2 = (Syi / (Sxi + Syi)) \cdot 100 \quad (II)$$

In the equation (II), Sxi represents the contact area of the lateral ridge 61 in the inside portion and Syi represents the contact area of the longitudinal ridge 63 in the inside portion. The ridge 59 is formed to have the ratio R2 of 70% to 100%. Also in some cases in which the inside portion has no lateral ridge 61 but is constituted by only the longitudinal ridge 63, the sliding performance and the nonslip performance are excellent. The ratio R2 is more preferably 75% to 95% and is particularly preferably 80% to 90%.

In some cases, the contact portion of the sole includes things other than the ridge 59. For example, the same contact portion includes a projection having an irregular array, a

cylindrical projection, a pattern such as a trade name or the like in some cases. In these cases, a portion which does not correspond to the lateral ridge 61 and the longitudinal ridge 63 is excluded and the ratios R1 and R2 are thus calculated.

If the tennis shoes having the sole 55 are used, a tennis play can be carried out more smoothly. In an actual tennis play, the ground is kicked by the toe portion when a movement is to be started in a forward direction. Then, the whole foot comes in contact with the ground in the final stage of the movement. When the movement is to be carried out in a transverse direction, moreover, the ground is kicked by the inside portion of an outer foot (for example, a left foot in a movement in a rightward direction) at the start of the movement.

In other words, a force is applied to the toe portion during the forward movement and is applied to the inside portion during the transverse movement. During a simultaneous slip and stoppage in the final stage of the movement, furthermore, the whole bottom face acts. In the sole 55, the ridge 59 is provided in an orthogonal direction to the direction of the force in a portion in which the force is to be received. Consequently, the nonslip performance can be enhanced. Since the longitudinal ridge 63 is provided at a proper ratio in the sole 55, a frictional resistance is reduced. Thus, the slip performance can be enhanced.

Fig. 10 is a perspective view showing a part of the sole 55 in Fig. 9 as seen from below. In Fig. 10, the base 57 and the lateral ridge 61 are shown. Fig. 11 is an enlarged sectional view showing a part of Fig. 10. As is apparent from Figs. 10 and 11, the sectional shape of the lateral ridge 61 is asymmetrical. The lateral ridge 61 has a contact surface 67, a toe side wall surface 69 and a heel side wall surface 71. The contact surface 67 comes in contact with a ground when tennis shoes are put on. The toe side wall surface 69 is linked to

the contact surface 67 and is positioned on a toe side from the contact surface 67. The heel side wall surface 71 is linked to the contact surface 67 and is positioned on a heel side from the contact surface 67.

In Fig. 11, an inclination angle θa of the toe side wall surface 69 is smaller than an inclination angle θb of the heel side wall surface 71. The sole 55 is suitable for use over an artificial turf having sand. In the case in which the tennis shoe is put on the artificial turf having sand and is pulled in the toe direction, a tensile force is mainly applied to the toe side wall surface 69. Since the inclination angle θa of the toe side wall surface 69 is small, a coefficient of friction μa between the ground and the bottom face is small. In the case in which a player slides the shoes, a sliding direction thereof is set to be the toe direction. Since the tennis shoe has the small coefficient of friction μa, a sliding performance is excellent. A player putting on the tennis shoes can smoothly carry out a transition from a movement to a stroke. A slide also contributes to the relaxation of a shock in a landing.

In the case in which the tennis shoe is put on the artificial turf having sand and is pulled in the heel direction, a tensile force is mainly applied to the heel side wall surface 71. Since the inclination θb of the heel side wall surface 71 is great, a coefficient of friction μb between the ground and the bottom face is great. In the case in which the player kicks the ground to move forward, a kicking direction thereof is set to be the heel direction. Since the tennis shoe has the great coefficient of friction μb, a nonslip performance is excellent in the kicking.

In respect of the consistency of the sliding performance and the nonslip performance, a ratio ($\mu a/\mu b$) of the coefficient of friction μa to the coefficient of friction μb is preferably equal to or lower than 0.9 and is more preferably

equal to or lower than 0.7. If the ratio ($\mu a/\mu b$) is too low, an unintended slip is apt to be caused in the toe direction. For this reason, the ratio ($\mu a/\mu b$) is preferably equal to or higher than 0.3 and is more preferably equal to or higher than 0.5.

It is preferable that a height H of the lateral ridge 61 should be 1 mm to 8 mm. In some cases in which the height H is smaller than the range, the nonslip performance is insufficient. From this viewpoint, it is more preferable that the height H should be equal to or greater than 2 mm. In some cases in which the height H is greater than the range, the stiffness of the lateral ridge 61 is insufficient. From this viewpoint, it is more preferable that the height H should be equal to or smaller than 6 mm.

It is preferable that a ratio (L2/L1) of a distance L2 of a contact surface 19 to a distance L1 of a boundary portion between the base 57 and the lateral ridge 61 should be 0.2 to 0.8. In some cases in which the ratio (L2/L1) is smaller than the range, the stiffness of the lateral ridge 61 is insufficient. From this viewpoint, it is more preferable that the ratio (L2/L1) should be equal to or higher than 0.3. In some cases in which the ratio (L2/L1) is higher than the range, a contact pressure becomes lacking so that the nonslip performance is insufficient. From this viewpoint, it is particularly preferable that the ratio (L2/L1) should be equal to or lower than 0.6.

The deforming behavior of the ridge 59 in the case in which the tennis shoes are to be used in a hard court is different from that of the ridge 59 in the case in which the tennis shoes are to be used in the artificial turf court having sand. In case of the tennis shoes to be used in the hard court, it is preferable that the inclination angle θa of the toe side wall surface should be greater than the inclination angle θb of the

heel side wall surface.

Fig. 12 is an enlarged sectional view showing a part of the sole 55 in Fig. 9. In Fig. 12, the base 57 and the longitudinal ridge 63 are shown. In Fig. 12, a left side indicates an inside and a right side indicates an outside. As is apparent from Fig. 12, the longitudinal ridge 63 includes a contact surface 73, an inside wall surface 75 and an outside wall surface 77. An inclination angle θc of the inside wall surface 75 is smaller than an inclination angle θd of the outside wall surface 77. The outside wall surface 77 contributes to a nonslip performance in a change in a direction. Since the inclination of the inside wall surface 75 is gentle, the area of the contact surface 73 is small in the longitudinal ridge 63. By the contact surface 73 having the small area, a contact pressure is raised. A high contact pressure contributes to an enhancement in the nonslip performance.

It is preferable that the inclination angle θc of the inside wall surface 75 should be 30 degrees to 70 degrees. On the other hand, it is preferable that the inclination angle θd of the outside wall surface 77 should be 50 degrees to 90 degrees. In respect of the nonslip performance, a difference (θd - θc) is preferably equal to or greater than 10 degrees and is more preferably equal to or greater than 20 degrees. If the difference (θd - θc) is preferably equal to or smaller than 60 degrees and is more preferably equal to or smaller than 50 degrees.

It is preferable that a height H of the longitudinal ridge 75 should be 1 mm to 8 mm. It is preferable that a ratio (L4/L3) of a distance L4 of the contact surface 73 to a distance L3 of the boundary portion between the base 57 and the longitudinal ridge 63 should be 0.2 to 0.8.

It is preferable that a ratio of the total area of all the contact surfaces to the projection area of the bottom face

should be 15% to 70%. If the ratio is lower than the range, the contact surface is apt to be worn out. From this viewpoint, it is more preferable that the ratio should be equal to or higher than 25%. In some cases in which the ratio is higher than the range, the contact pressure becomes lacking so that the nonslip performance is insufficient. From this viewpoint, it is more preferable that the ratio should be equal to or lower than 60%.

Fig. 13 is a bottom view showing a part of a sole 79 according to a further embodiment of the present invention. The sole 79 also comprises a ridge 81. The ridge 81 includes a truncated pyramid-shaped projection 83 and a truncated cone-shaped projection 85. As is apparent from Fig. 13, in the case in which a plurality of projections is continuously stripe-shaped in the present invention, the whole projections are referred to as one ridge 81.

Fig. 14 is a bottom view showing a sole 91 of a tennis shoe according to a further embodiment of the present invention. In Fig. 14, an upper side indicates a toe side, a lower side indicates a heel side, a right side indicates an outside and a left side indicates an inside. The sole 91 is used for a left foot. A sole for a right foot takes a shape obtained by inverting the shape shown in Fig. 14. The sole 91 includes a base 93, a plurality of lateral ridges 95 and a plurality of longitudinal ridges 97. The lateral ridge 95 and the longitudinal ridge 97 are formed integrally with the base 93 and are protruded from the base 93. The lateral ridge 95 is extended in a transverse direction. The longitudinal ridge 97 is extended in a longitudinal direction.

Fig. 15 is an enlarged bottom view showing a part of the sole 91 in Fig. 14. In Fig. 15, the lateral ridge 95 is shown. Upper and lower sides in Fig. 7 indicate toe and heel sides, respectively. The lateral ridge 95 is formed by continuously arranging a projection 99 including a contact surface taking

a circular shape and a projection 99 including a contact surface taking the shape of a dumbbell. The longitudinal ridge 97 is also formed by continuously arranging a projection including a contact surface taking a circular shape and a projection including a contact surface taking the shape of a dumbbell (see Fig. 14), which is not shown in Fig. 15. The lateral ridge 95 includes a wall surface 103 having a small inclination angle on a toe side and a wall surface 105 having a great inclination angle on a heel side. The longitudinal ridge 97 includes a wall surface having a small inclination angle on an inside and a wall surface having a great inclination angle on an outside, which is not shown in Fig. 15.

In the sole 91, a ratio R1 is 40% to 70% and a ratio R2 is 70% to 100%. In the sole 91, a coefficient of friction μa in a toe direction is smaller than a coefficient of friction μb in a heel direction. A ratio ($\mu a/\mu b$) of μa to μb is 0.3 to 0.9. Tennis shoes having the sole 91 is excellent in both a nonslip performance and a sliding performance.

In the sole 91, an arcuate projection 107 is formed on a point where the lateral ridge 95 and the longitudinal ridge 97 cross each other. By the arcuate projection 107, the lateral ridge 95 and the longitudinal ridge 97 are provided smoothly and continuously. In the sole 91, a crack is caused with difficulty.

EXAMPLE

[Experiment 1]

[Example 1]

A rubber composition containing a styrene-butadiene copolymer as a base material was put in a mold to cause a crosslinking reaction over the rubber. Thus, a sole was obtained. The pattern of the bottom face of the sole is shown in Fig. 2. The sole has a large number of lateral ridges formed

thereon. The lateral ridge has an inclination angle θa of 30 degrees, an inclination angle θb of 90 degrees, a height H of 3 mm and (L2/L1) of 0.25. A midsole constituted by an ethylene-vinylacetate copolymer and an upper constituted by cotton were attached to the sole so that tennis shoes according to an example 1 were obtained.

[Examples 2 and 3 and Comparative Examples 1 and 2]

Tennis shoes according to examples 2 and 3 and comparative examples 1 and 2 were obtained in the same manner as in the example 1 except that the mold was changed and a sole comprising a lateral ridge taking a shape shown in the following Table 2 was formed.

[Example 4]

Tennis shoes according to an example 4 were obtained in the same manner as in the example 1 except that the mold was changed and a sole comprising lateral and longitudinal ridges taking shapes shown in the following Table 1 was formed. The pattern of the sole is shown in Fig. 7.

[Test for Practical Use]

A player was caused to put on tennis shoes and to carry out the rally of tennis at an artificial turf court having sand (a trade name of "OMNICOURT" manufactured by SUMITOMO RUBBER INDUSTRIES, INC.). The easiness of a change in a direction, a nonslip performance in a start, a sliding performance and a tired feeling of legs were evaluated in five stages of "1" to "5". The highest evaluation was indicated as "5". An average value of the evaluations for ten players is shown in the following Table 1. As shown in the Table 1, an outsole according to each of the examples has excellent evaluation results for all items.

Table 1 Result of evaluation

		Compara. Example 1	Example 1	Example 2	Example 3	Compara. Example 2	Example 4
Pattern of bottom face		Fig. 2	Fig. 2	Fig. 2	Fig. 2	Fig. 2	Fig. 7
Lateral ridge	Inclination angle θa (degree)	20	30	50	80	90	50
	Inclination angle θb (degree)	90	90	90	90	90	90
	$\theta b - \theta a$ (degree)	70	60	40	10	0	40
	Height H (mm)	3	3	3	3	3	3
	L1 (mm)	8	8	6	6	6	6
	L2/L1	0.10	0.25	0.45	0.75	1.00	0.50
Longitudinal ridge	Inclination angle θc (degree)	-	-	-	-	-	50
	Inclination angle θd (degree)						90
	$\theta d - \theta c$ (degree)						40
	Height H (mm)						3
	L3 (mm)						6
	L4/L3						0.50
$\mu a/\mu b$		0.1	0.3	0.6	0.9	1.0	0.6
Easiness of change in direction		3	3	3	3	3	5
Nonslip performance in start		5	5	5	5	5	5
Sliding performance		Excessive sliding	4	5	4	1	5
Tired feeling of leg		3	4	5	4	1	5

[Experiment 2]

[Example 5]

A rubber composition containing a styrene-butadiene copolymer as a base material was put in a mold and was vulcanized. Thus, a sole was obtained. The pattern of the bottom face of the sole is shown in Fig. 9. The sole has a plurality of lateral ridges and a plurality of longitudinal ridges formed thereon. A ratio R1 of the contact area of the lateral ridge to the total contact area of the ridges in a toe portion is 50% and a ratio R2 of the contact area of the longitudinal ridges to the total contact area of the ridges in an inside portion is 90%. A midsole constituted by an ethylene-vinylacetate copolymer and an upper constituted by cotton were attached to the sole so that tennis shoes according to an example 5 were obtained.

[Example 6 and Comparative Examples 4 and 5]

Tennis shoes according to an example 6 and comparative examples 4 and 5 were obtained in the same manner as in the example 5 except that the mold was changed and a sole having a specification shown in the following Table 2 was formed.

[Comparative Example 3]

A trade name of "CT592" put on the market and sold from New Balance Japan Co., Ltd. was prepared for a comparative example 3.

[Test for Practical Use]

A player was caused to put on tennis shoes and to carry out the rally of tennis at an artificial turf court having sand (a trade name of "OMNICOURT" manufactured by SUMITOMO RUBBER INDUSTRIES, INC.). Thus, a nonslip performance in a forward movement, and a nonslip performance and comfortableness in a movement in a transverse direction were evaluated in five stages of "1" to "5". The highest evaluation was indicated as "5". An average value of the evaluations for ten players is shown in the following Table 2. As shown in the Table 2, an outsole

according to each of the examples has excellent evaluation results for all items.

Table 2 Result of evaluation

	Compara. Example 3	Compara. Example 4	Compara. Example 5	Example 5	Example 6
Ratio R1 (%)	0	100	0	50	60
Ratio R2 (%)	0	0	100	90	80
Nonslip performance in forward movement	3	5	1	4	5
Nonslip performance in movement in transverse direction	3	1	5	5	4
Comfortableness	3	2	2	4	5

INDUSTRIAL APPLICABILITY

Tennis shoes according to the present invention are suitable for a play in various courts. The tennis shoes are more suitable for a court having a small coefficient of friction (an artificial turf court having sand and a clay court). In particular, the tennis shoes are suitable for the artificial turf court having sand. The tennis shoes can contribute to an enhancement in the game result of a player.